Optimal compensation contracts under asymmetric information concerning expected earnings*

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Abstract. We analyze a model with two-dimensional asymmetric information where the employer has better information about the firm's earnings potential and the employee is subject to moral hazard. The employee's contract consists of an annual bonus and stock options. We focus on two issues: how different degrees of asymmetric information about short-term earnings versus long-term earnings affect optimal contracts and second, if a signalling equilibrium exists, what information concerning the firm's performance profile over time can be conveyed by the choice of contract. We show that if the extent of long-term (short-term) asymmetric information is larger, short-term (long-term) compensation prevails. With regard to signalling, we show that firms offering more options have higher short-term performance and lower long-term performance. This provides new insights into the structure of earnings-based compensation. For example, this is consistent with evidence that stock options are inversely related to the timeliness of accounting numbers or to the extent to which current earnings incorporate value-relevant information and that firms issuing stock options for employees outperform other firms shortly after the issue while there is no significant difference in the long run.

JEL classification: D82, J33, M12, M52

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1 Introduction

The structure of compensation contracts is an important issue in accounting and corporate governance literature. This paper is based on the existence of asymmetric information between an employer and a worker. The literature dealing with asymmetric information related to the employer-worker relationship usually assumes that private information is held by potential workers (such as their ability level, for instance). In the present paper, an employer has private information about a firm's earnings potential. Existing literature on implicit contracts (pioneered by Azariadis, 1983) studies similar situations. This literature analyzes the level of unemployment, the problem of wage rigidity and other macroeconomic questions. It also typically considers one-dimensional asymmetric information: there are good and bad types of firms and the extent of asymmetry does not vary over time. Considerations such as risk-sharing, the trade-off between work and leisure, and the technology of production play an important role in these models. However, the structure of compensation contracts is not usually the focus. This paper focuses on earnings-based compensation which has been used in an increasing number of contracts in recent years. Our analysis includes its two most important components: annual bonuses and stock options.

Hayes and Schaefer (2005) focus on a bonus-fixed wage structure in a situation where insiders have ex-post private information from observing the outcome of their employees' effort before the stock market's participants. An employee's bonus thus relies on relational contracts (Baker, Gibbons and Murphy, 1994) and non-verifyable information.[1] We analyze a signaling game where employers have ex-ante private information vis-a-vis the potential employees and the market participants and this information is two-dimensional: the employers have private information about the amounts and timing of future expected earnings.[2] As in implicit contract literature, firms may have private information about their productivity which leads to asymmetric infor-

[1] The authors analyze how the value of **a** firm's reputation and the weights of short-term share price and long-term share price in the firm's objective function affect the optimal bonus payment. In particular, it is shown that if the value of a firm's reputation is not sufficiently large then greater concern for short-term share price means succesful firms can credibly commit to pay larger bonuses to avoid mimicking by unsuccesful firms. This explains why the insiders' myopia and short-termism may lead to higher profits.

[2] Lambert (2001) noticed that a set-up where the principal (employer) has private information about strategic variables is interesting for analyzing compensation related issues.

mation about expected earnings. Asymmetric information about the timing of earnings may take place because: 1) corporations typically employ long-term strategic planning, giving the employer private information for several years and; 2) the employer may have private information about allowance for bad debts, recognition of sales not yet shipped, estimation of pension liabilities, capitalization of leases and marketing expenses, delay in maintenance expenditures and delay in production etc.[3]

We argue that an employer's private information about a firm's performance profile over time significantly affects the optimal structure of earnings-based compensation contracts which remain puzzling from a "pure" moral hazard or agency theory viewpont (see, among others, Core, Guay and Verechia (2003), Murphy (1999), Lambert (2001) and Yermack (1995, 1997)). We focus on the following questions: what information about **a** firm's earnings potential can be conveyed by the choice of employees' compensation contracts, in particular why the use of stock options may be negatively correlated with a firm's future performance (contrary to the usual moral hazard predictions); how different degrees of asymmetric information about short-term earnings versus long-term earnings affect the optimal contract; and why short-term earnings-based compensation may prevail over long-term compensation.

More specifically, we consider a two-period situation where, in each period, a firm must hire a worker. This is done by offering a compensation contract contingent on first-period earnings (such as an annual bonus, for instance) or second-period earnings (stocks or options). Workers may accept or reject the contract according to their beliefs about the firm's earnings profile over time which they try to ascertain from the offered contract. After accepting the contract, the worker chooses the level of effort they will provide. In this game the degree of asymmetric information regarding short-term and long-term earnings may vary. Asymmetry regarding long-term earnings is high when information about short-term prospects is publicly available while long-term performance is unknown. This may be the case when short-term performance relies on past decisions which are publicly observable while long-term performance may depend on strategic decisions which are not disclosed. Long-term asymmetry may also be high when there is asymmetric information regarding the entrepreneurial skills of top-management. Asymmetric

[3] Miglo (in press) and Miglo and Zenkevich (2006) analyze the effect of private information concerning the timing of earnings on capital structure.

information regarding short-term earnings is high when the firm has important private short-term information like delays in production while there is little asymmetry regarding long-term information. This can also be the case when the quality of accounting technology is low or when monitoring is very expensive.

We show that if the extent of long-term asymmetric information is larger, short-term compensation prevails. If short-term private information is more important, long-term compensation prevails. This is consistent with evidence provided by Bushman, Chen, Engel and Smith (2004). The authors show that stock options are inversely related to the timeliness of accounting numbers or to the extent to which current earnings incorporate value-relevant information. If the asymmetry regarding current earnings is high, the relationship between current earnings and firm value is low. It is also consistent with evidence that a higher proportion of management ownership is observed in firms where more monitoring is required (Demsetz and Lehn, 1985), and that management ownership across countries varies inversely with the quality of a country's accounting disclosure policies (La Porta, Lopez-de-Silanes and Vishny, 1998).

With regard to signalling, we show that a separating equilibrium exists if asymmetric information regarding the timing of cash flows is larger than that regarding total cash flows. To provide basic ideas about the separating equilibria and how private information about a firm's profit profile over time can affect contract choice let us suppose that there are only two types of firms. One is "performance-improving" and has an increasing expected profit, while others are "stagnant" and have a flatter or decreasing expected profit. In such an environment, equilibrium contracts can be affected by the "lemon" effect in both the short run and long run.[4] Intuitively, the performance-improving type appears to have an informational advantage in the short run: lower profits in this period mean that this type of firm can capitalize on the adverse selection problem. In the long run the informational advantage passes to the stagnating type. A separating equilibrium exists if the types have no incentive to mimic each other. If the performance-improving type wants to separate itself in equilibrium it will offer a contract which puts high weight on the first period such as an annual bonus (as opposed to stock options).

[4] We use the phrase "lemon" problem to describe a situation where private information leads to the underpricing of the "good" type (Akerloff, 1970).

The rest of this paper is organized as follows. The basic model is described in Section 2. Sections 3 and 4 analyze the optimal design of compensation contracts under asymmetric information. The model implications and empirical evidence are discussed in Section 4. The conclusion is presented in Section 5.

2 Model.

Consider a firm with a two-stage production process. In each stage $t = 1, 2$, earnings $\widetilde{r}_t$ depend on a worker's effort and the firm's productivity. For simplicity assume that there are two levels of effort e_t. If $e_t = 0$ then $\widetilde{r}_t = 0$. If $e_t = 1$, production can either be successful or unsuccessful. If the former is the case, $\widetilde{r}_t = 1$ and if the latter is the case, $\widetilde{r}_t = 0$. There are two types of firms. For type g ("good") the probability of success in the first period equals θ_{g1} and that in the second period equals θ_{g2}. Type b ("bad") has parameters θ_{b1} and θ_{b2}. By definition, g has better overall performance than b: $v_g > v_b$, where $v_x = \theta_{x1} + \theta_{x2}$ is firm $x^{'}$s total expected earnings over the two periods. Let μ_0 be the proportion of type g firms, $0 < \mu_0 < 1$. Let $\widehat{\theta}_t = \theta_{gt}\mu_0 + \theta_{bt}(1 - \mu_0)$ ("average firms' performance in period t"). In each period, $e_t = 1$ costs the Worker c. We assume that the θ's are restricted to the interval $(c, 1]$, which implies that $e_t = 1$ is socially optimal and production is profitable in each period. Stages are technologically dependant. If $e_1 = 0$ then, regardless the effort in the second period, $r_2 = 0$.

At the beginning of each period the Employer (the firm's owner or the Directors Board) offers a contract to the Worker. The Worker may accept or reject the offer. If the offer is rejected then the payoff to both parties equals 0. If the offer is accepted then the Worker chooses e_1. The same scenario repeats in the second period after the parties observe r_1. The Worker's payoff is a fraction of the firm's profit. The first-period contract contains two numbers: an annual bonus representing a fraction (f_1) of first-period earnings and a portfolio of stock options which give the Worker the right to purchase a fraction (f) of the firm's shares (it is assumed for simplicity that the exercise price equals 0) at the end of the first period.[5] Selling

[5]The assumption concerning zero exercise prices is not crucial. Also, the introduction of more kinds of compensation such as restricted stocks, long-term incentive plans or retirement plans in the contract will not alter the results. Both these remarks hold true as long as long-term compensation depends more on the firm's second-period earnings than

options at the beginning of the first period is prohibited. Companies often put restrictions of this nature on the sale of options at the beginning of a workers employment. Typically, options are not directly tradeable and secondly they become exercisable (i.e. the recipient is given the right to buy stocks) over time (Murphy, 1999). The second-period contract contains only the annual bonus of the Worker which is represented by a fraction of the second-period profit (f_2). We assume limited liability for both parties:

$$0 \leq f_t \leq 1 \text{ and } 0 \leq f \leq 1 \tag{1}$$

$$f_2 + f \leq 1 \tag{2}$$

If $f_1 < f$ the equity-based component (long-term incentive) prevails in the first-period contract and vice versa. Let α_t denote the proportion of earnings retained by the Employer in period t. Clearly,

$$\alpha_1 = 1 - f_1 \text{ and } \alpha_2 = 1 - f_2 - f \tag{3}$$

There exists universal risk-neutrality in this economy. For simplicity it is assumed that the Worker's reservation payoff in each period equals 0. The second-period incentive constraint for the Worker is that his expected second-period payoff is not smaller than c. We also assume the existence of a perfect capital market for shares. At the end of first period the Worker can sell a portion of their shares. We denote the remaining fraction of shares by f_n. In the first period, the Worker's incentive constraint (assuming that the second-period incentive constraint holds) is that his expected net payoff from supplying $e_1 = 1$ (which includes the first-period bonus, the value of shares sold at the end of the first period, and the second-period payoff minus c) is not less than c.[6] The Employer knows the firm's type, but the Worker does not. The distribution of types is common knowledge. The contracts are enforceable at no cost.

The sequence of events is illustrated in Figure 1. We assume that the firm's type is revealed to the Employer in period 0. Throughout this article, we use the concept of Perfect-Bayesian equilibria and also verify that

on first-period earnings. This is even the case for restricted stocks because they usually have different timing constraints (Murphy, 1999).

[6]The Worker is ready to exchange the cost of effort for consumption in either the first or second period. This can be interpreted as a perfect credit market with a risk-free interest rate equal to 0. This allows workers to transfer funds between periods.

off-equilibrium beliefs survive standard refinements such as Cho and Kreps' (1987) intuitive criterion and mispricing. The usage of these criteria in a game without repetition where the informed party moves first is quite common in existing literature.[7]

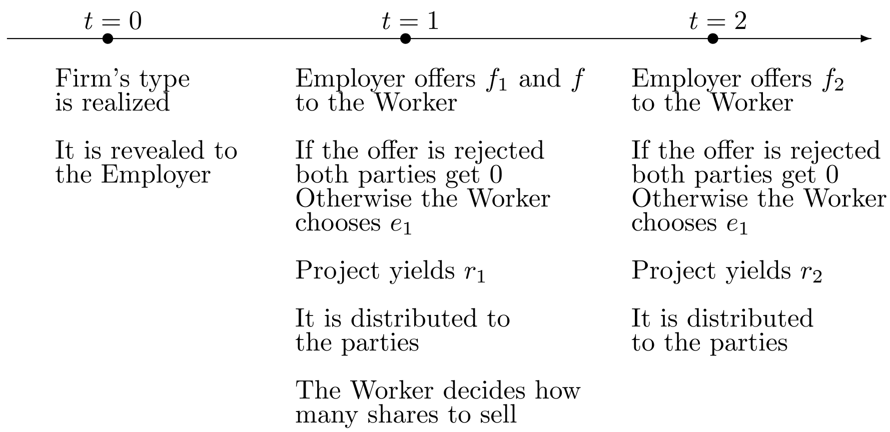

Figure 1. The sequence of events.

2.1 Symmetric information.

This subsection provides some useful information about benchmark contracts when the Worker knows the firm's type. The relations describing the parties' decisions and payoffs are:

1) the second-period incentive constraint for the Worker:

$$c \leq (f_n + f_2)\theta_2 \tag{4}$$

If it holds then $e_2 = 1$. Otherwise $e_2 = 0$.

2) the choice of f_2 by the Employer:

$$f_2 = \arg\max E[(1 - f_2 - f_n)r_2] \tag{5}$$

[7] See, for instance, Diamond (1991, 1993), Myers and Majluf (1984) or Nachman and Noe (1994).

3) the firm's market value at the end of the first period equals $V_1 = \theta_2$ if the capital market believes that the Worker will supply $e_2 = 1$ (i.e. condition (4) holds) and zero otherwise.

4) the Worker's decision to sell shares:

$$f_n = \arg\max[(f - f_n)V_1 + \max\{0, (f_n + f_2)\theta_2 - c\}] \tag{6}$$

where $(f - f_n)V_1$ represents the value of shares sold by the Worker and $\max\{0, (f_n + f_2)\theta_2 - c\}$ is the Worker's expected second-period payoff.

5) the first-period incentive constraint for the Worker:

$$c \leq f_1\theta_1 + (f - f_n)V_1 + \max\{0, (f_n + f_2)\theta_2 - c\} \tag{7}$$

6) the Employer's payoff is

$$\Pi = \alpha_1 r_1 + \alpha_2 r_2$$

Given (3) we can write

$$\Pi = (1 - f_1)r_1 + (1 - f_2 - f)r_2 \tag{8}$$

The Employer's problem is to maximize the expected value of (8):

$$f_1, f = \arg\max E[(1 - f_1)r_1 + (1 - f_2 - f)r_2] \tag{9}$$

Proposition 1. *When information is symmetric:*

$$f_2 = c/\theta_2 \tag{10}$$

$$c = f_1\theta_1 + f\theta_2 \tag{11}$$

$$V_0 = E\Pi = \theta_1 + \theta_2 - 2c \tag{12}$$

(all mathematical proofs are collected in the Appendix).

From (10), the fraction of second-period earnings offered to the Worker, is positively related to the cost of effort and negatively related to the firm's expected performance in that period. The logic behind (11) is similar. Eq. (12) implies that in the case of perfect information, the value of the firm (for the Employer) does not depend on the structure of the compensation contract (short-term versus long-term) offered to the Worker as long as conditions (10) and (11) hold. For instance one can have a contract with a very small f_1 as well as a contract with a very small f.

3 Signalling by the choice of compensation contract.

Now suppose that the firm's type is the Employer's private information. We start with an efficient separating equilibrium where each type of Employer gets the first-best return (12). From (10) and (11) the strategy of the Employer can be completely described by only one variable. Take f_1 for convenience. Let $V_{km}^{f_1}$ be the expected payoff to the Employer of type k if strategy f_1 is played and the type is perceived by the Worker as type m; $k, m \in \{g, b\}$. A separating equilibrium is a situation where type g plays strategy f_{1g}, type b plays strategy f_{1b} and neither type has an incentive to mimic the other.

$$V_{gb}^{f_{1b}} \leq V_{gg}^{f_{1g}} \tag{13}$$

$$V_{bg}^{f_{1g}} \leq V_{bb}^{f_{1b}} \tag{14}$$

Given limited liability and that if the contract is rejected, the payoff to the firm equals 0, only accepted contracts are a part of equilibrium. Therefore, the value of $V_{km}^{f_1}$ depends on the performance of type k and the issued contracts which in turn depend on the Worker's beliefs about the firm's type (type m).

$$V_{km}^{f_1} = (1 - f_{1m})\theta_{k1} + (1 - f_{2m} - f_m)\theta_{k2} \tag{15}$$

where from (10) and (11):

$$f_m = \frac{c - f_{1m}\theta_{m1}}{\theta_{m2}} \tag{16}$$

$$f_{2m} = c/\theta_{m2} \tag{17}$$

We also know from Proposition 1 that $V_{xx}^{f_{1x}} = v_x - 2c, x \in b, g$.

Lemma 1. *If* $\theta_{gt} \geq \theta_{bt}, t = 1, 2$ *an efficient separating equilibrium does not exist.*

Intuitively, if the good type (g) has better performance in both periods then any contract issued by this type has a higher value than that issued by type b. Therefore the latter always mimics type g. Thus, a necessary condition for the existence of an efficient separating equilibrium is one of the following. Either $\theta_{g1} > \theta_{b1}$ and $\theta_{g2} < \theta_{b2}$ or $\theta_{g2} > \theta_{b2}$ and $\theta_{g1} < \theta_{b1}$. We will now continue with these two cases. The values of different contracts depend in different ways on the firm's expected performance in each period. Since each type performs differently in each period the value of contracts offered by different types are different. To avoid mimicking, type g will offer contracts which put more weight on the earnings in the period when it underperformes type b. Thus, in the first case, we expect that type g will offer a contract with a large number of stock options while in the second case it will offer a large bonus. In a separating equilibrium, type b will offer the opposite contracts.

The analysis of conditions (13) and (14) leads to the following result.

Proposition 2. *If* $\theta_{g1} > \theta_{b1}$ and $\theta_{g2} < \theta_{b2}$ *then a separating equilibrium exists if and only if*

$$\frac{\theta_{g1}\theta_{b2} - \theta_{b1}\theta_{g2}}{\theta_{g1} - \theta_{b1}} \geq 2c \tag{18}$$

Furthermore if a separating equilibrium exists then

$$f_{1b} \geq f_{1g}$$

2) if $\theta_{g2} > \theta_{b2}$ and $\theta_{g1} < \theta_{b1}$ *then a separating equilibrium exists if and only if*

$$\frac{\theta_{b1}}{\theta_{g1}} + \frac{\theta_{b2}}{\theta_{g2}} \geq 2 \tag{19}$$

Furthermore if a separating equilibrium exists then

$$f_{1b} \leq f_{1g}$$

Proposition 2 implies that firms which have better performance in the first period and weaker performance in the second period will offer a lower fraction of short-term bonuses to the Worker. Consider the interpretation of conditions (18) and (19). Two ideas underline the analysis below. First, when the difference between firms' total values is large enough a separating equilibrium does not exist. This is because the type with a low total value will mimic the high value type. A large difference in the firms' rates of earnings growth contributes to the existence of a separating equilibrium by making it possible for g to design debt claims which will not be mimicked by b. To see this let us rewrite (19) as follows:

$$\frac{v_b v_g (r_b - r_g)}{v_g(1 + r_b) - v_b(1 + r_g)} \geq 2c \tag{20}$$

$$\frac{v_b(r_g + r_b)(1 + r_g)}{v_g r_g (1 + r_b)} \geq 2 \tag{21}$$

where $r_x = \theta_{x2}/\theta_{x1}$ is the rate of earnings growth for type x. The condition $r_x > 1$ means that a firm has an increasing earnings profile, $r_x < 1$ and $r_x = 1$ means that the firm has a decreasing or flat earnings profile respectively.

Corollary 1. *A separating equilibrium exists if and only if the following holds: 1) the extent of asymmetric information regarding firms' total values is sufficiently small and; 2) the extent of asymmetric information regarding firms' performance profiles over time is sufficiently large.*

Figure 1 illustrates Corollary 1. Here $r_g = 1.5, v_g = 1.6, \theta_{g1} = 0.64, \theta_{g2} = 0.96$ and $c = 0.4$. The figure shows the values of r_b and v_b for which separating equilibriums may exist. In the space between the thick lines (F_2) a separating equilibrium does not exist. In F_1 and F_3 a separating equilibrium exists. Note that for any value of v_b a separating equilibrium exists if r_b differs sufficiently from r_g and for any r_b a separating equilibrium exists if v_b is high enough (close to v_g). In other words, a separating equilibrium exists if asymmetric information about rate of earnings growth is more important than that concerning the firms' total values.

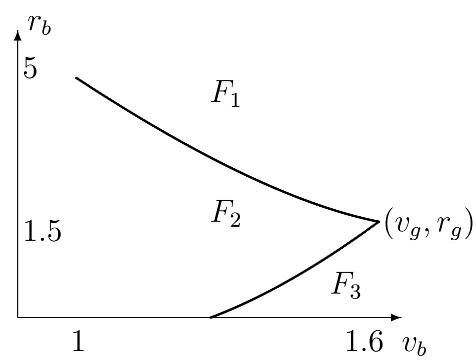

Figure 1. Separating equilibria.

4 Pooling equilibria.

Let us turn to the analysis of pooling equilibria where both types play the same strategies in both periods: f_1, f, f_2.[8] The relations describing the parties' decisions and payoffs are:

[8]Note that a separation in the second period cannot exist after pooling in the first. Indeed, suppose the opposite is true and in the second period one type offers a lower

1) the second-period incentive constraint for the Worker:

$$c \leq (f_n + f_2)(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2}) \tag{22}$$

where μ_2 is the Worker's belief at the beginning of period 2 that the type is g. According to Bayes rule:

$$\mu_2 = \frac{\mu\theta_{g1}}{\mu\theta_{g1} + (1-\mu)\theta_{b1}} \text{ if } r_1 = 1$$

$$\mu_2 = \frac{\mu(1-\theta_{g1})}{\mu(1-\theta_{g1}) + (1-\mu)(1-\theta_{b1})} \text{ if } r_1 = 0$$

2) the firm's market value at the end of the first period equals $V_1 = \mu_2\theta_{g2} + (1-\mu_2)\theta_{b2}$ if the capital market believes that the Worker will supply $e_2 = 1$ (i.e. condition (22) holds) and zero otherwise.

3) the Worker's decision to sell shares:

$$f_n = \arg\max[(f - f_n)V_1 + \max\{0, (f_n + f_2)(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2} - c\}] \tag{23}$$

where $(f - f_n)V_1$ represents the value of shares sold and $\max\{0, (f_n + f_2)(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2} - c\}$ is the Worker's expected second-period payoff.

4) the first-period incentive constraint for the Worker:

$$c \leq f_1\theta_1 + E[(f - f_n)V_1 + \max\{0, (f_n + f_2)(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2} - c\}] \tag{24}$$

5) the payoff to the Employer of type x is

$$V = (1 - f_1)\theta_{x1} + (1 - f_2 - f)\theta_{x2} \tag{25}$$

Lemma 2. *If a pooling equilibrium exists then*

$$c = f_1\widehat{\theta_1} + f\widehat{\theta_2} \tag{26}$$

$$f_2 \equiv f_2(r_1) = c/\widetilde{\theta}_2(r_1) \tag{27}$$

where

$$\widetilde{\theta}_2(r_1) = \mu_2\theta_{g2} + (1-\mu_2)\theta_{b2}$$

fraction of earnings to the Worker than the other type. If this offer is accepted, the other type will obviously mimic this strategy. Otherwise this strategy cannot be a part of equilibrium given the limited liability of the Employer.

Note that in contrast to the symmetric information case, f_2 depends on μ_2 and r_1 because the Worker updates his beliefs about the firm's type after observing first-period earnings. From (27) and (26) the equilibrium strategy can be completely described by only one variable. Take f_1 for convenience. Let $V_x^{f_1}$ be the expected payoff to the Employer of type x in the case of a pooling equilibrium with f_1. A pooling equilibrium is a situation where both types play strategy f_1, off-equilibrium worker's beliefs about observing an off-equilibrium strategy f_{1off} are that the firm is type g with probability $\mu_{off}(f_{1off})$ and

$$V_x^{f_1} \geq V_x^{f_{1off}}, x \in b, g \tag{28}$$

We have:

$$V_g^{f_1} = \theta_{g1}(1 - f_1 + (1 - f_2(1) - f)\theta_{g2}) + (1 - \theta_{g1})(1 - f_2(0) - f)\theta_{g2} \tag{29}$$

where $f_2(r_1)$ is given by (27) and from (26)

$$f = (c - f_1\widehat{\theta_1})/\widehat{\theta_2}$$

In a pooling equilibrium type g is underpriced. Thus, we will look for a pooling equilibrium which minimizes the mispricing of type g. The mispricing is the difference between the Employer's first-best return $\theta_{g1} + \theta_{g2} - 2c$ and its equilibrium payoff $V_g^{f_1}$.

Proposition 3. *Pooling with* $f_1 = \frac{c}{\widehat{\theta_1}}$ *minimizes mispricing if and only if* $\frac{\theta_{g2}}{\theta_{b2}} \geq \frac{\theta_{g1}}{\theta_{b1}}$; *pooling with* $f_1 = \frac{\max\{0, c - (1 - c/\max\{\widetilde{\theta_2}(0), \widetilde{\theta_2}(1)\})\widehat{\theta_2}\}}{\widehat{\theta_1}}$ *minimizes mispricing if and only if* $\frac{\theta_{g2}}{\theta_{b2}} < \frac{\theta_{g1}}{\theta_{b1}}$.

The intuition behind Proposition 3 is that if $\theta_{g2}/\theta_{b2} \geq \theta_{g1}/\theta_{b1}$ the extent of uncertainty regarding long-term cash flows is large. In this case optimal contracts put as much weight as possible on the first period (from (26) the maximal value of f_1 is $c/\widehat{\theta_1}$) to reduce the "lemon" effect of asymmetric information and vice versa.

Finally note that, if an inefficient separating equilibrium exists (one where type b has its first-best payoff in equilibrium while type g is undervalued because it offers a larger annual bonus (or larger fraction of stock) than in the symmetric information case to avoid being mimicked by b) then mispricing is larger than in a pooling equilibrium described in Proposition 3. Proof of this is omitted for brevity but is available upon request.

5 Implications.

(i) The present paper argues that asymmetric information regarding the timing of a firm's performance profile over time may affect the structure of earnings-based compensation contracts for employees. In particular, it explains when it motivates firms to issue stock options for employees and when to use annual bonuses. From Proposition 1, a firm's compensation policy is irrelevant when information is symmetric. It is relevant when information is asymmetric as implied by Propositions 2 and 3.

Jensen and Meckling (1976) argue that stocks or stock options link an employe's wealth with a firm's value thus mitigating moral hazard and agency problems. Since then numerous extensions of this theory have been developed. However, as mentioned in the introduction, the debates concerning the degree to which the "pure" agency theory is able to explain numerous puzzling phenomena about compensation contracts, are still open. Also note that Yermack (1995, 1997) analyzes the determinats of top executives' options grants and concludes that agency theory does not explain observed data. Oyer and Schaeffer (2004) do not find any support for moral hazard explanations for why firms issue options to employees. Another theory is based on employees' risk-aversion. It argues that options, by introducing convexity into their payoffs, can improve otherwise conservative decision-making by employees. However, this idea has been challenged by Carpenter (2000) and Ross (2004), who argue that options can actually increase managers' aversion to risk. Among other approaches note: inducing employees to sort, helping firms retain employees and tax consideration. While all of them find some empirical support, none is considered a major idea behind the usage of stock options in theoretical literature.

Sloan (1993) argues that earnings-based bonuses are used because share prices contain "macroeconomic" noise. However, Easton, Harris, and Ohlson (1992) provide strong evidence that earnings equal stock price changes over long horizons, which means both prices and earnings are equally susceptible to macroeconomic "noise" over the long run. Paul (1993) and Feltham and Xie (1994) demonstrate the usefulness of earnings because they provide disaggregate information about buisiness units or tasks. However, it does not explain why aggregate earnings are widely used in compensation contracts. Barclay, Gode and Kothari (2003) suggest that earnings better match the delivered performance by a manager while share prices also include expected future performance. The authors argue that price-based compensation (stocks or stock options) will lead to the overpayment of managers in the short run. The empirical confirmation of the latter thoery has not yet been done.

(ii) The model predicts that short-term incentives will prevail if the extent of asymmetric information in the first period is lower than that in the second period and vice versa. This is implied by Proposition 3. $\theta_{g2}/\theta_{b2} < \theta_{g1}/\theta_{b1}$ means that the extent of uncertainty about future earnings is lower than that in the first period. Instead, if $\theta_{g2}/\theta_{b2} > \theta_{g1}/\theta_{b1}$, stock options will prevail. In addition to the evidence provided in the introduction, note that Hayes and Schaefer (2000) find that incentive plans become relatively more reliant on insiders' private information about firms' future performance when the precision of current accounting information decreases.

(iii) It follows from Proposition 2 and Corollary 1 that if the extent of asymmetric information regarding firms' total values is small enough (compared to the extent of asymmetric information regarding the performance profile over time) then a separating equilibrium may exist. This equilibrium implies that firms which offer higher fractions of equity (through options) in their compensation contracts have higher operating performance in the short-run and lower operating performance in the long-run (as compared to firms which offer fewer options). This is type b if $\theta_{g2} > \theta_{b2}$ and $\theta_{g1} < \theta_{b1}$ and is type g if $\theta_{g2} < \theta_{b2}$ and $\theta_{g1} > \theta_{b1}$.

Empirical literature produces different evidence regarding the impact of compensation contracts on firms' future operating performance. However, the following papers are noteworthy. Palia (1998) and Himmelfarb, Hubbard and Palia (1998) find a positive association between operating income and management ownership. This is consistent with the stagnating type having higher earnings in the first period and issuing more options for employees than the performance-improving type. Yermack (1997) shows that firms issuing stock options for employees outperform other firms shortly after the issue while there is no significant difference in the long run. Cheng and Farber (2006) find that among firms which experience financial restatement those which decrease the portion of stock options in managers' compensation contracts perform better in the long term. It has also been observed (Gilson and Vetsuypens, 1994) that firms in financial distress (with a projected decrease in cash flows) offer a higher fraction of stock options in their compensation structure and a lower fraction of bonus or cash-based compensation. While all these papers provide some data which is similar to the spirit of the present paper, a complete test of the results in point (iii) must be based on identifying firms with high uncertainty regarding the timing of cash flows and low uncertainty regarding total cash flows. One can use the spread in analysts' valuations of firms' shares as a proxy for the extent of asymmetric information regarding the firms' total values and the spread in the forecasts of future earnings (long-term spread versus short-term spread) as a proxy for asymmetric information about future rates of earnings growth. Also, as mentioned above, firms manipulating earnings can be seen as ones with a high degree of asymmetric information about the timing of earnings since earnings management can often be seen as a redistribution of earnings between periods rather than accounting fraud (Degeorge et al, 1999).

As an alternative explanation for why using options for employees may lead to long-term underperformance, Gao and Shrieves (2002) argue that a high proportion of options in compensation contracts provides an incentive to engage in earnings manipulation by pumping earnings into periods when their portfolios of options are large. Thus, less effort will be allocated to production activities. This argument only works if agents are not able to rationally anticipate such opportunistic behavior. In this case, managers and employees can mislead the stock market by dressing earnings. We share the idea that insiders can be involved in earnings management leading to asymmetric information about the firm's performance profile over time. However, our explanation is based on completely rational agents.

Issuing more options to workers leads to an increase in equity capital. Thus, our findings are also consistent with the well-known phenomenon that firms issuing equity underperform other firms in the long run and outperform them in the short run (see, among others, Jain and Kini (1994) and Loughran and Ritter (1997)).

6 Conclusion.

Lambert (2001) suggested that the private information of insiders may affect the structure of compensation contracts. This paper analyzes the structure of earnings-based compensation contracts (annual bonuses versus stock options) when employers have private information about the firms' qualities and workers are subject to moral hazard. The paper explains how asymmetric information can affect firms' compensation policies. The model predicts that short-term incentives will prevail if the extent of short-term asymmetric information is low relative to long-term asymmetric information. It is also shown that among firms with potentially high degrees of asymmetric information regarding the timing of earnings (for instance, among firms involving in earnings management) those offering more stock options in compensation packages outperform in the short-run and underperform in the long-run. A discussion of empirical implications of these results is provided.

Appendix

Proof of Proposition1. Under symmetric information the first-best solution can be obtained in the following manner. First, note that in equilibrium (4) and $e_2 = 1$ cannot hold simultaneously with $c > f_2\theta_2$. In this case, $V_1 = \theta_2$ and from (6) the Worker's payoff is $(f + f_2)\theta_2 - c$ which is less than $f\theta_2$. Thus, the Worker will sell their shares at the beginning of $t = 2$ and chose $e_2 = 0$. Therefore, if the second-period constraint is satisfied in equilibrium then $c \leq f_2\theta_2$. From (5) the firm is interested in minimizing f_2 by making sure that (4) holds. If (4) does not hold then from (5) the firm's second-period payoff is 0. Therefore, $f_2 = c/\theta_2 - f_n$. Together with $c \leq f_2\theta_2$ this implies $f_n = 0$ and $f_2 = c/\theta_2$. From (7) $c = f_1\theta_1 + f\theta_2$ and from (9) $V_0 = E\Pi = \theta_1 + \theta_2 - 2c$. *End proof.*

Proof of Lemma 1. Suppose the opposite is true and such an equilibrium exists. Let g play the strategy f_{1g}. It follows from (16), (17) and $\theta_{gt} > \theta_{bt}$ that $V_{bg}^{f_{1g}} = (1 - f_{1g})\theta_{b1} + (1 - f_{2g} - f_g)\theta_{b2} > \theta_{b1} + \theta_{b2} - 2c$. *End proof.*

Proof of Proposition 2. First consider $\theta_{g2} > \theta_{b2}$ and $\theta_{g1} < \theta_{b1}$. Proof of necessity. From (15), (16) and (17), the incentive constraint (13) for type g holds if and only if:

$$f_{1b} \leq A \tag{30}$$

where

$$A = \frac{2c(\theta_{g2} - \theta_{b2})}{\theta_{b1}\theta_{g2} - \theta_{g1}\theta_{b2}} \tag{31}$$

The incentive constraint (14) for type b holds if and only if:

$$f_{1g} \geq A \tag{32}$$

This proves $f_{1b} \leq f_{1g}$. Now from (1) and (16) we have:

$$f_{1g} \leq c/\theta_{g1} \tag{33}$$

From (32) and (33)

$$c/\theta_{g1} \geq A$$

By (31) this can be rewritten as the condition (19).

Sufficiency. Suppose that (19) holds and consider a situation with $f_{1g} = c/\theta_{g1}$ and $f_{1b} = 0$. The incentive constraint for b holds because of (19) and the above argument. The incentive constraint for g holds noting that $A > 0$.

Now consider $\theta_{g2} < \theta_{b2}$ and $\theta_{g1} > \theta_{b1}$. Necessity. From (15), the incentive constraint (13) for type g holds if and only if:

$$f_{1b} \geq A \tag{34}$$

The incentive constraint (14) for type b holds if and only if:

$$f_{1g} \leq A \tag{35}$$

This proves $f_{1b} \geq f_{1g}$. From (2) and (17) we have:

$$f_g \leq 1 - c/\theta_{g2} \tag{36}$$

Now from (1), (16) and (36):

$$f_{1g} \geq (2c - \theta_{g2})/\theta_{g1} \tag{37}$$

From (35) and (37)

$$(2c - \theta_{g2})/\theta_{g1} \leq A$$

This can be rewritten as (18).

Sufficiency. Suppose that (18) holds and consider a situation with $f_{1g} = (2c - \theta_{g2})/\theta_{g1}$ if $2c > \theta_{g2}$ and $f_{1g} = 0$ if $2c \leq \theta_{g2}$ and $f_{1b} = c/\theta_{b1}$. The incentive constraint for b holds because of (18). The incentive constraint for g holds noting that $c/\theta_{b1} > A$ because $\frac{\theta_{g1}}{\theta_{b1}} + \frac{\theta_{g2}}{\theta_{b2}} \geq 2$. *End proof.*

Proof of Corollary 1. Consider the case $r_g \geq r_b$. First we show that if a separating equilibrium exists then $r_g \geq 1$. From Proposition 2, if a separating equilibrium exists then (21) holds. Since the left side of (21) is increasing in v_g it should also be $\frac{(r_g+r_b)(1+r_g)}{r_g(1+r_b)} \geq 2$. This implies $r_g \geq 1$. Take the partial derivatives of left of (21). We have: $\partial(.)/\partial r_b < 0; \partial(.)/\partial r_g > 0; \partial(.)/\partial v_b > 0; \partial(.)/\partial v_g < 0$. This implies that (21) holds if: 1) r_b is sufficiently small (other parameters being equal); 2) v_b is sufficiently large; 3) r_g is sufficiently large and; 4) v_g is sufficiently small. Now consider the case $r_b > r_g$. From

Proposition 2, if a separating equilibrium exists then (20) holds. The rest follows from analyzing the partial derivatives of left side of (20). *End proof.*

Proof of Lemma 2. In equilibrium (22) cannot hold simultaneously with $c > f_2(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2})$. In this case $V_1 = \mu_2\theta_{g2} + (1-\mu_2)\theta_{b2}$ and from (23) the Worker's payoff is $(f+f_2)(\mu_2\theta_{g2}+(1-\mu_2)\theta_{b2}) - c$ which is less than $f(\mu_2\theta_{g2}+(1-\mu_2)\theta_{b2})$. Thus, the Worker will sell their shares at the end of $t = 1$ and chose $e_2 = 0$. Therefore, if the second-period constraint is satisfied in equilibrium then $c \leq f_2(\mu_2\theta_{g2}+(1-\mu_2)\theta_{b2})$. Now consider f_2. Both types are better off with f_2 being as small as possible. To achieve this they must make sure that (22) holds. If (22) does not hold then, from (5), the firm's second-period payoff is 0. Therefore, $f_2 = c/(\mu_2\theta_{g2}+(1-\mu_2)\theta_{b2}) - f_n$. Together with $c \leq f_2(\mu_2\theta_{g2} + (1-\mu_2)\theta_{b2})$ this implies $f_n = 0$ and $f_2 \equiv f_2(r_1) = c/\widetilde{\theta}_2(r_1)$, where $\widetilde{\theta}_2(r_1) = \mu_2\theta_{g2} + (1-\mu_2)\theta_{b2}$. In contrast to the symmetric information case, f_2 depends on μ_2 and r_1. From (24) $c = f_1\widehat{\theta}_1 + f\widehat{\theta}_2$. *End proof.*

Proof of Proposition 3. From (29) $\frac{\partial V_g^{f_1}}{\partial f_1} = -\theta_{g1} + \frac{\widehat{\theta}_1\theta_{g2}}{\widehat{\theta}_2}$. Thus, if $\frac{\theta_{g2}}{\theta_{b2}} \geq \frac{\theta_{g1}}{\theta_{b1}}$, f_1 should be maximized. From (26) it is $f_1 = \frac{c}{\widehat{\theta}_1}$. Otherwise f_1 should be minimized. A minimal f_1 corresponds to a maximal f. From (2) and (27) $f \leq 1 - c/\max\{\widetilde{\theta}_2(0), \widetilde{\theta}_2(1)\}$. This condition, together with (1) and (26), implies $f_1 \geq \frac{\max\{0, c-(1-c/\max\{\widetilde{\theta}_2(0),\widetilde{\theta}_2(1)\})\widehat{\theta}_2\}}{\widehat{\theta}_1}$. To prove that these pooling equilibria exist and that they satisfy the Cho-Kreps intuitive criterion, first note that since a separating equilibrium minimizes mispricing compared to pooling we only consider the cases when (18) and (19) do not hold. Also, a strategy where at least one incentive constraint for the Worker is not satisfied is always dominated, for all types of Employers, by a strategy where both incentive constraints hold (given limited liability). It holds, whatever the Worker's beliefs are, when they observe such a strategy out off equilibrium. Thus, no type of Employer will deviate to such a strategy. Therefore, we consider only the off-equilibrium strategies for which both incentive constraints hold (for some beliefs). For this set of strategies the off-equilibrium beliefs supporting equilibrium are that when observing strategy j_{off} the Worker believes that the type is b. Thus, type b does not deviate from the equilibrium because its equilibrium payoff exceeds its first-best payoff. Also, type g does not deviate. To see this note that from (18), (19) and (29), $\partial V_g^{f_1}/\partial\mu > 0$. The off-equilibrium beliefs satisfy the Cho-Kreps intuitive criterion because type b has the potential to earn more than its equilibrium payoff if the beliefs are that the type is g since $\partial V_b^{f_1}/\partial\mu > 0$. *End proof.*

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